

Solutions Network Formulation Report

The Potential Contributions of the Global Precipitation Measurement Mission to Estuary Management in Acadia National Park

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1. Candidate Solution Constituents

- a. Title: The Potential Contributions of the Global Precipitation Measurement Mission to Estuary Management in Acadia National Park
- b. Authors: Daniel Anderson, Kent Hilbert, David Lewis
- c. Identified Partners: USGS (U.S. Geological Survey), National Parks Service
- d. Specific DST/DSS: Acadia National Park NLERDSS (Nutrient Load and Estuarine Response Decision Support System)
- e. Alignment with National Application: Coastal Management, Water Management, Ecological Forecasting
- f. NASA Research Results – Table 1:

Missions	Sensors/Models	Data Product
GPM (Global Precipitation Measurement)	GMI (GPM Microwave Imager) DPR (Dual-frequency Precipitation Radar)	Rainfall Rate, Droplet Size

- g. Benefit to Society: The restoration and protection of estuaries within Acadia National Park.

2. Abstract

This candidate solution suggests the use of GPM precipitation observations to enhance the Acadia National Park NLERDSS. Simulated GPM data should provide measurements that would enable analysis of how precipitation affects runoff and nutrient load in the park's wetlands. This solution benefits society by aiding park and resource managers in making predictions based on hypothetical changes and in identifying effective mitigation scenarios. This solution supports the Coastal Management, Water Management, and Ecological Forecasting National Applications.

3. Detailed Description of Candidate Solution

- a. Purpose/Scope

Excessive nutrient enrichment of estuaries often leads to eutrophication and the associated loss of biological diversity and habitat value. Recent national assessments confirm that coastal eutrophication is widespread and is increasing in the United States, and that the impact of excess nutrients is the

most important pollution problem confronting U.S. coastal systems. This significant pollution problem causes increased areas and amplified severity of hypoxic and anoxic waters, alteration of food webs, degradation and loss of sea grass beds, kelp beds and coral reefs, loss of biodiversity, and increased incidences and duration of harmful algal blooms (Scavia, 2006).

Acadia National Park lies along the rugged lowlands of Maine's eastern coast. Acadia was the first national park established east of the Mississippi River and is a place of incredible biodiversity: both terrestrial and aquatic. Today Acadia protects 47,000 acres of ocean, forests, lakes, and mountains (NPS, 2006). Baseline investigations have highlighted the susceptibility of Acadia's estuaries to nutrient inputs and to the threats posed by changes in land use outside the park's boundaries. Subsequently, The Resource Management Plan for Acadia National Park identifies nutrient loading to aquatic systems as one of the park's most significant resource management challenges (UMESC, 2006). Approximately 80 species of freshwater plants can be found in the park along with an additional dozen semi-aquatic shoreline species. Seven of these aquatic or semi-aquatic species are either currently listed or are proposed for listing on Maine's Official List of Endangered and Threatened Plants, while about 30 other species are considered "locally rare." These plants are important members of the aquatic community, providing shelter and nesting sites to a variety of fishes and other animals and serving as an important food source for mammals, waterfowl, and turtles (NPS, 2006).

b. Identified Partner(s)

The USGS UMESC (Upper Midwest Environmental Sciences Center) conducts research mostly in the Upper Midwest but has projects in at least 23 states. It is generally involved in ecological and population impact issues. UMESC has developed a GIS-based DSS for the National Parks Service. This DSS is used to quantify the effects of land use change within the watershed on nutrient loading to the estuary. The Acadia National Park NLERDSS consists of two tools: the NLERT (Nutrient Load and Estuarine Response Tool) and the LUPET (Land Use Polygon Edit Tool).

The NLERT is used to calculate nutrient loading to the Northeast Creek estuary based solely on land use composition within the Northeast Creek watershed. Land use data is derived from color infrared aerial photography. Within NLERT, total nutrient load is calculated by multiplying the area of each land use type within the watershed by the nutrient export coefficient of each land use type, and then summing these values. The NLERT compares the nutrient loading statistics of a selected area of interest to the watershed as a whole and also predicts long-term estuarine ecosystem responses to the level of nutrient loading based on numerical thresholds calculated in situ. The user also has the ability to make hypothetical area changes and nutrient coefficient value changes to the area of interest to quantify these changes (UMESC, 2006).

The LUPET allows the user to make predictive approximations by enabling alterations to the land use composition within the watershed through spatially explicit changes to the GIS theme. This capability allows the user to quantify the effects of land use change (e.g., increased urbanization) within the watershed on the level of nutrient loading to the estuary.

The tools allow park resource managers to work with local governments to reduce or alter locations of deforestation or urban development and to work with local farmers to minimize the impact of agricultural fertilizers. While beneficial, the current DSS data is not timely because it only looks at one variable, land use, which seldom changes. Supporting the model with precipitation measurements would allow the tool to provide information in step with rainfall events that are likely cause high runoff. Mitigation scenarios, such as nutrient capture, can be implemented based on this data.

c. NASA Earth-science Research Results

The GPM mission builds on the success of the Tropical Rainfall Measuring Mission. GPM will provide more accurate, frequent, global, high spatial resolution and microphysically detailed measurements of precipitation than its predecessor. GPM is attempting to make the most comprehensive and accurate measurements of global precipitation ever obtained. This objective will be accomplished through an advanced core satellite with a first-of-its-kind dual frequency radar and passive microwave radiometer that will provide key measurements of precipitation physics and will serve as a calibrator for an international constellation of new and previously existing satellites (referred to as satellites of opportunity).

The core satellite is scheduled to launch in 2013. Each member of the constellation will carry some type of passive microwave radiometer, will provide global and temporal sampling, and will also reduce error uncertainty (NASA, 2006). GPM is also composed of a comprehensive precipitation processing system and an international GV (ground validation) effort. An international GV network will be required because of both the variability in the types of rainfall and the effects of geographical location and geomorphologic features on precipitation events (Smith et al., 2007). The task of ensuring success of the network falls to a 16-nation alliance plus the European Union (NASA, 2007). The configuration of the constellation satellites allows for a 3-hour revisit time for any point on the globe, while the core satellite's sensors will allow for spatial resolutions approaching 250 km.

d. Proposed Configuration's Measurements and Models

An extensive body of science details the utility and functionality of models that attempt to describe precipitation, groundwater, and streamflow processes. In fact, development of mathematical models relating precipitation incidents on a catchment to the streamflow emanating from the catchment has been a major focus of surface water hydrology for decades. This candidate solution proposes modelling precipitation measurements along with other meteorological data in addition to land use types within the watershed.

A simple model is proposed to incorporate the impacts of rainfall events in the Northeast Creek catchment. One of the major problems in rainfall-runoff modeling is dealing with over-parameterization. Through the application of several models of varying complexity over a number of small catchments, studies by both Loague and Freeze (1992, p. 245) and Hornberger et al. (1995) seem to suggest that simpler, less data-intensive models provide as good or better predictions than models that require extensive physical data input (Jakeman and Hornberger, 1993). Simplicity is also preferred by the NLERDSS project team because of the varied level of technical proficiency possessed by users of the tools. For these reasons, a model with only minimal parameters is suggested.

Land use data that is collected only periodically via aerial photography is the most important parameter to this model. Simulated GPM precipitation data, temperature, and solar radiation should be suitable parameters to determine the scope of impact that rainfall events have on the local watershed. In this scenario, the PRMS (Precipitation-Runoff Modeling System) detailed by Leavesley et al. (1983) is suggested for use to enhance the Acadia NLERDSS. PRMS is a modular modeling system that has been developed to evaluate the impacts of various combinations of precipitation, climate, and land use on surface-water runoff, sediment yields, and general basin hydrology (Leavesley et al., 1983). The addition of rainfall observations to the model benefits the overall DSS by allowing for a real-time component that affects nutrient load instead of relying on averaged static estimates based on land use alone.

4. Programmatic and Societal Benefits

The Acadia National Park NLERDSS is used to help park resource managers protect the important but sensitive estuarine ecosystems in and around Acadia National Park. Population growth, expanded land development, and intensified agriculture will most likely increase nutrient loads substantially in the future. The tools developed as a part of the NLERDSS are meant to assess and forecast the impacts based on those changing land use characteristics. This candidate solution proposes strengthening the tools by adding precipitation measurements to the model, which already evaluates land use characteristics. The precipitation data would enable more timely and accurate estimates of eutrophic conditions in the park estuaries. For these reasons, this solution strongly supports Coastal Management, Water Management, and Ecological Forecasting National Applications while also supporting Agricultural Efficiency to a lesser degree.

5. References

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